CARDIO-CHARTING

Universal Method of Recording
Heart Auscultation

CARDIO-CHARTING

Universal Method of Recording Heart Auscultation

ARTHUR BRISKIER, M.D.

Senior Clinical Assistant Physician and Cardiologist, Mount Sinai Hospital, New York City Assistant Physician, Cardiac Department, French Hospital, New York City

New York - 1957

THE MACMILLAN COMPANY

First printing, August, 1957.

Printed in the United States of America

Library of Congress catalog card number 57-9364

Foreword

Dr. Briskier has elaborated in much interesting detail a graphic method . . . , to illustrate the findings of cardiac auscultation. To the usual symbols denoting sounds and murmurs he has added color (blue for sounds and red for murmurs), intensity, timing, character or quality (for example, musical or grating and crescendo or diminuendo), direction of transmission, and even the position of the body during the auscultation. Thus, in a very small compass one can illustrate clearly what one hears without the need of a long descriptive paragraph. Such a visual technique has the further advantage, as stated by Dr. Briskier, of quick application internationally without concern about the particular country or language of the author of the graphic record.

Paul Dudley White, M.D.

Boston, Mass.
July, 1956

Preface

It is well known that Hippocrates used direct auscultation over two thousand years ago on the Greek island of Kos, and that, nearly one hundred and fifty years ago, mediate stethoscopic auscultation was practiced by Laennec in Paris.

Either direct or mediate auscultation of the heart reveals sounds with their rates and rhythms, as well as murmurs with their characteristic modulations Thus, many cardiac abnormalities can be recognized during a clinical examination; a correct diagnosis leads to an appropriate medical or surgical treatment.

In questionable cases, instrumental graphs have been introduced. These are occasionally helpful in confirming or ruling out a clinical suspicion. A tracing, although important, shows only quantitative characteristics of sounds and murmurs, whereas the actual listening to the beating *and sounding heart gives the clinician the true picture of the patient's cardiac status* Sounds and murmurs should therefore be heard, not seen, because there is an inherent quality to the sound-wave which cannot be transformed into a visual pattern Just as one cannot hear a color, blue or red, *it is equally impossible to see a sound or a murmur* It is true that visualizations have been made of sounds, but these show only the length of time during which a sound takes place, as well as a few other characteristics, such as amplitude and frequency, the sound itself, as such, remains invisible

While I was a medical student in Paris, it occurred to me that a unified method of charting the findings of heart auscultation was necessary. At that time, and also probably still today, the medical histories were recorded on the back of the temperature sheets Thus it was often easy to read the occasional differences of opinion among the examiners, each one of them thinking of a different murmur or of a different rhythm, while considering the same patient Besides the problem of the subjectivity of audible perceptions, the great difficulty was inherent in the absence of a unified method of charting Indeed, the longhand chartings of a physical examination could not be easily compared because of the absence of a common system of notation It is self-evident that in controversial cases a correct diagnosis could be established neither early nor easily, due both to the subjectivity of examination and lack of a unified method.

Since then, I have had the opportunity to witness that, in all countries which I have visited, the same differences of opinion exist because of a lack of a standardized system of notation of cardiac acoustic phenomena. Yet most of the other parts of a physical examination were and are recorded satisfactorily and in a standardized way, such as blood pressure, temperature, pulse, respiration, etc.

Moreover, today, auscultation is somewhat neglected, and this is perhaps partly due to the absence of a unified method which would enable each examiner to objectivate his individual findings. The modern procedures, such as cardiac surgery and laboratory tests (cardiac catheterization, stethography, vectorcardiography, plethysmography, ballistocardiography, shift of electrolytes, etc.), also contribute to lessen the use of auscultation and, even, to render questionable the value of physical diagnostic methods Thus, auscultation is replaced by *visualization* (cardiograms, ballistocardiograms, stethograms), or by the surgeon's intracardiac *palpation* in the operating room.

New methods come and go. Some remain. But auscultation which has been practiced for over two thousand years is here to stay. Undoubtedly, it is necessary, even for auscultation, to keep pace with changing times.

A new, simple, clear, and concrete method, based on self-explanatory colored symbols—Cardio-Charting—is here presented. Due to the modern character of some of its symbols, and the colors (blue for sounds, red for murmurs), this standardized method might help to restore auscultation to its primary place of importance Once having been heard, a sound or a murmur can be recalled at a later date by the association of a sound with one particular color (blue), and a murmur with another particular color (red). Furthermore, not only the sounds and murmurs are thus recalled, but also their characteristics can be visualized equally well by a given shape which will be the closest mental picture of that particular acoustic phenomenon under consideration. Thus the auditory findings can be charted by the clinician and kept as a permanent, visual, shorthand record.

Auscultation is the most important clinical examination of the heart; yet no unified system of charting the physical findings was ever available. Such a system, as Cardio-Charting, will be helpful not only for the practitioners, but for teaching purposes as well. The necessity of charting his own clinical findings in a standardized way would compel the physician to listen more carefully during auscultation of the heart. The use of a single, unified method will also result in a more objective presentation of various individual auditory perceptions and their interpretations Subjective variations can also be minimized, because of the symbols representing the individual findings. Indeed, it is self-evident that, following a clinical examination of a heart by many physicians, the majority of concording symbolic chartings will undoubtedly correspond to the actual cardiac acoustic phenomena, and thus

the application of this standardized method will result in a correct and early diagnosis.

Through extensive lecturing about my method in many countries of different languages, I became convinced that Cardio-Charting is not only a standardized method, but that this method is also universal. Indeed, Cardio-Charting was instantly understood wherever demonstrated, because of the blue and red symbols.

In order to be accepted and generally used, such a system must have definite advantages over the previously attempted methods, including the generally used longhand notation; it should be concrete, unified, clear, easy to apply, timesaving, and universally understandable. I do hope that my method fulfills these conditions.

I trust that the aim of this contribution to clinical medicine will be achieved when professors of clinical medicine will teach Cardio-Charting and the practicing physician will use it.

Some of the material in this book, familiar to all experienced physicians, and more so to cardiologists, is given here for the benefit of students.

Cardio-Charting is not only a standardized method of notation which will help to restore auscultation to its primary place of importance, it is also a system which will help to promote the establishment of a world-wide common language through which all physicians could express objectively their own individual perceptions and understand each other's charting of cardiac auscultatory findings.

New York City
June, 1957

A.B.

Illustrations

Contents

1. Introduction

Auscultation is the most important clinical method of examining the heart, and has been practiced for a long time by a majority of physicians in all parts of the world, however, no standardized method of charting is available

Many individual notations and graphic charts have been used, but none is satisfactory and none is generally accepted.

Individual Notations

Each clinician uses his own personal method of charting his findings Consequently, his records are either too long or too short; often they are incomplete or illegible, and, occasionally, the chart can be understood only by the author himself.

It is essential for physicians to have a permanent, unified, and universally understandable chart Among the many reasons are the following

1 Since auscultation is a subjective examination, performed individually, it is not easy to know what an examiner actually hears when listening to a heart, and it is difficult for the examiner himself to remember compare, discuss, or convey his findings

2. It is important to learn to "write" clearly and uniformly what one hears while listening to a heart, and it is equally important to "read" what other observers have "heard" and charted in their records.

3 Often, during auscultation of the heart, it is not easy to distinguish a sound from a murmur Furthermore, when the presence of a murmur is established, its origin may be in doubt

4 At times, when listening to the same heart, clinicians hear different murmurs, each seemingly having a different origin Thus, for one listener the murmur is systolic, and aortic in origin, for another, the same murmur seems to be systolic but pulmonic in origin, for a third, the murmur is both systolic and diastolic, originating from the pulmonary area, for

still another, it is a systolic midcardiac murmur. In such a case, a proper diagnosis cannot be established, since the first clinician thought of an aortic stenosis; the second, of a pulmonary stenosis; the third, of a patent ductus arteriosus; and the fourth, of an interatrial defect.

This confusion would be at least partially avoided if the clinician would chart his findings in a standardized way. Moreover, the necessity of presenting visually the auscultatory findings would compel the physician to listen more carefully and to chart more exactly what he actually hears. Two major advantages will result: (1) an earlier and a precise diagnosis, and (2) a permanent and accurate record of auscultation.

Graphic Charts

Although auscultation is the art and science of listening, there is a growing tendency to use the eyes instead of the ears whenever the acoustic cardiac phenomena are considered. Indeed, nowadays heart sounds and murmurs are not only mechanically reproduced, but they are also visualized in the form of graphic charts, just as if they were *visible*, not *audible*. Whatever their unquestionable value (for example, timing), these graphic charts, however, are not a faithful reproduction of what the ear hears; but what the microphone picks up and transmits for amplification. Furthermore, the graphic tracing represents sounds and murmurs as identically alike. Only the ear can, and does, discriminate one from the other, since listening is more accurate and analytic than seeing. In some respects, the ear is more perfect than the eye. Indeed, it is impossible to see each individual color separately when many colors are mixed together, whereas it is easy to distinguish each sound produced by each individual instrument when listening to an orchestra playing. A graphic tracing not only fails to show the place of origin of a given murmur, but also mixes both sounds and murmurs. In fact, a graphic tracing does not always say whether it is a sound or a murmur which has been recorded. If it is a sound, it does not say whether it is the first or the second. (Occasionally, a third or a fourth sound might be heard and recorded.) If it is a murmur, the tracing does not show whether it is systolic or diastolic; and if the murmer is systolic, it does not say whether it is mitral or aortic, for example. It is evident that, whatever its merit, a tracing is incomplete and confusing, similarly, conventional longhand charting is personal and insufficient (Fig I).

Just as musical sounds cannot be adequately conveyed through words, but only through musical notes, similarly, the heart sounds and murmurs with all their characteristics cannot be recorded faithfully through words, but only through appropriate symbols.

Here is a simple
hand description ar
as compared with

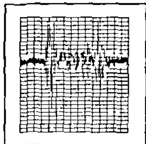
1. *Usual longhand description*·

> A murmur is heard in the mitral area, in the fifth intercostal space, covering the entire systole The murmur is loud, blowing, and rough in character, grade III in intensity, crescendo, radiating upward and outward toward the left axilla. It has a musical component high in pitch and is best heard when the patient is in a recumbent position. The pulse beats 80 per minute.

Should such a note be legible, it would require space for writing, time for reading, and imagination.

2. *Graphic tracing* (stethogram) of the same murmur.

This tracing requires explanation and interpretation



3 *Cardio-Charting*

This picture speaks for itself

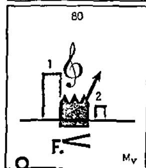


Figure I. Comparison between the usual methods and Cardio-Charting

A colored shorthand charting with blue symbols for sounds and red for murmurs, although visual, is the closest presentation of the cardiac acoustic phenomena actually perceived by the examining ear and interpreted by the clinician. The colored symbols translate instantly the sounds and murmurs. Indeed, a picture speaks for itself; it is self-explanatory and can take the place of a long descriptive paragraph. Often, while examining a heart, murmurs, if present, may be heard, and the diagnosis can be established without any instrumental or laboratory aid. Seeing on the chart a red symbol alone will instantly remind the physician of the presence of a murmur. Every time a clinician looks at his blue and red symbols, he will in his memory hear again and again the auscultatory findings he charted in the past. This is not due to the symbols alone, but to the presence of red–blue colors where the red symbol is unmistakable and instantly associated with a murmur. Furthermore, Cardio-Charting has even a larger scope—it will help not only to bring back to the observer his own clinical findings, but it will also create a clinical picture of auscultatory cardiac phenomena for those who are looking at the colored symbols, but who have never actually examined the patient. This way of charting is of great clinical significance. Neither longhand description nor any instrumental graphic tracing can translate a murmur as well as a colored symbol does. The described method requires no special studies. Indeed, the charting is easy to apply and simple to understand: blue for sounds, red for murmurs.

Some murmurs with musical components, which are difficult to describe otherwise with precision, are charted with symbols commonly used in music. Just as it is not necessary to be an artist in order to distinguish blue from red, similarly, it is not necessary to be a musician to differentiate a sound from a murmur.

Cardio-Charting will cover most of the characteristics of heart sounds and murmurs It does not intend to substitute a visual pattern for a sound, which actually should be heard. It does not attempt to standardize the clinical findings It will, however, be helpful for charting and reading these findings in a simple, clear, easy, conclusive, uniform, and universally understandable way.

A symbolic presentation of cardiac charting reveals instantly all characteristics of:

1. Heart sounds—normal or abnormal rhythms such as additional sounds, split sounds, gallop rhythms, bi- or trigeminal rhythms, extrasystoles, flutter, atrial fibrillation, etc , all this in *blue.*

2. Heart murmurs—their origin, duration, intensity, pitch, quality, radiation, position of the patient, place of maximum audibility, etc.; all this in *red.*

Such pictorial information requires only a few square centimeters of space and a few seconds of time. Thus, many clinical examinations can be charted side by side (see Fig. XI). A long illness, with all the changes that might take place, can be viewed instantly in the chronologic sequence of events. Cardio-Charting which uses only very simple colored symbols without any words has a universal application

The purpose of Cardio-Charting is to present the auscultation symbolically in a concrete and a precise way. It seems, therefore, useful to record in subsequent chapters some of the well-known facts which are usually mentioned in textbooks on cardiology.

HUMAN AUDIBILITY AND CARDIAC ACOUSTIC PHENOMENA (Fig. II)

Human Audibility

The range of human audibility is about 16 to 20,000 cycles per second. With advancing age, there is a gradual loss in hearing, the older one gets, the greater is the loss. Figure II shows (the curved lines) that at the age of:

31–40	years,	the	loss	in	hearing	is	10	decibels	(violet line)
41–50	"	"	"	"	"	"	20	"	(black line)
51–60	"	"	"	"	"	"	30	"	(blue line)
61–70	"	"	"	"	"	"	40	"	(red line)

Often, in youngsters, and without any apparent reason, the hearing is impaired, especially when heart murmurs are high in pitch or low in intensity or both.

Heart Sounds and Murmurs

The heart sounds are within the range of about 20 cycles per second and up to 150 cycles per second. Heart murmurs are within the limits of 30 to 1460 cycles per second. The presystolic murmurs are about 300 cycles per second; the systolic murmurs are up to 600 cycles per second; and the early diastolic murmurs are up to 1250 cycles per second. The low-pitched murmurs rarely reach 450 cycles per second, whereas the high-pitched murmurs are usually around 700 cycles per second.

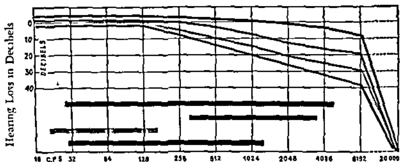
For demonstration purposes, it might be useful to show the range of human audibility in relation to the range of a piano, the human voice, and heart sounds and murmurs.

The piano covers the entire range of the human voice, as well as heart sounds and murmurs. Indeed, the lowest piano sound corresponds to about 28 cycles per second and the highest to over 4000 cycles per second; the human voice (bass, tenor, alto, and soprano) ranges from about 260 to about 4000 cycles per second.

In comparing the graphs of human audibilty with the frequency range of the cardiac acoustics, it becomes evident why the high-frequency cardiac murmurs are heard with difficulty.

AUSCULTATION OF THE HEART

As already mentioned, normally, one can hear two heart sounds: the first and the second, separated by two intervals: the first corresponding to the systolic, and the second, to the diastolic silence. Usually the first sound is shorter than the second. In general, it is easy to distinguish the first sound from the second. In questionable cases, the carotid pulse will help to determine the first sound. In children and in individuals with narrow chests, the sounds are heard more distinctly In individuals with large chests, in the presence of emphysema or pleural or pericardial effusion, the sounds may diminish in intensity or, even, become inaudible In some individuals, and for no apparent reason, the sounds are very clearly heard, and in others, on the contrary, the sounds are heard with great difficulty. This unexplained situation exists also during the recording of the sounds and murmurs for audible reproduction. Occasionally, a third, and also rarely a fourth, heart sound can be heard.



Upper curved lines			Lower lines
Age in years	31-40		human audibility 16 cps to 20,000 cps
	41-50	(violet line)	piano range 28 cps to 4138 cps
	51-60	(black line)	speech 260 cps to 4000 cps
	61-70	(blue line)	heart sounds 20 cps to 150 cps
		(red line)	heart murmurs 30 cps to 1460 cps

Figure II. Human audibility and cardiac acoustic phenomena

Analysis of Heart Sounds

Four sounds are described. There are many theories concerning their physiology; the consensus is not yet unanimous.

The first heart sound has four components: the *valvular* (closure of the mitral and the tricuspid valves), *atrial*, *ventricular*, and *vascular*. This sound is best heard in the apical region, in the fifth left interspace (depending on the size, shape, and the position of the heart). Its duration is about 0.18 to 0.22 second at the rate of 70 to 80 per minute. Its pitch is low, about 30 to 100 cycles per second; the number of vibrations is 7 to 15 per cardiac revolution (mention of electrocardiograms and stethograms is made here and elsewhere only for timing purposes); its relationship to the electrocardiogram is about 0.008 second before the R wave, and the sound tracing (stethogram) falls on the descending limb of the R wave.

The second heart sound is shorter and sharper than the first one. It is also characterized by four components The most important are: the *valvular* (closure of the aortic and the pulmonic valves) and the *vascular*. The second sound is best heard at the second left interspace, near the sternum, it is louder over the pulmonic than over the aortic area in youngsters, while in aged people it is better heard over the aortic area ($A_2 > P_2$). In pulmonary hypertension, P_2 is louder than $A_2 (P_2 > A_2)$. Its duration is about 0.06 to 0.10 second at the rate of 70 to 80 per minute. Its pitch is higher than the first sound, about 50 to 150 cycles per second. The number of vibrations is about 3 to 4. Its relationship to the electrocardiogram: the second heart sound starts 0 09 second after the summit of the T wave and falls on the descending limb of the T wave.

The third heart sound, which is not easily heard, is a normal, physiologic phenomenon in young people and in athletes. It appears early in the diastole, after the second sound, and is due to ventricular contraction (vibration) and, for some diagnosticians, to the sudden upward movement of the atrioventricular valve Two components are described· the *muscular* (distention) and the *vascular* (filling). This sound is best heard at the apex, during expiration, with the patient in the left lateral decubitus, and the lower extremities elevated. Its duration is 0 04 to 0 06 second at the rate of 60 to 72 per minute Its pitch is very low: 20 to 40 cycles per second. The number of vibrations is 1 to 3. Its relationship to the electrocardiogram: 0 01 second following the T wave.

The fourth heart sound is usually inaudible, but is occasionally heard in a quiet room It is an atrial sound, produced by 2 to 5 vibrations and recorded graphically, particularly in complete heart blocks

Heart Murmurs

Concurrent with heart sounds, *murmurs* can be present. These are *additional noises* of a great variety. Murmurs may be congenital or acquired, functional or organic, cardiac or extracardiac. Whatever their etiology, they will always be indicated by red symbols

While the heart sound has a percussive quality, the murmur usually has a blowing quality. In general, it is easy to distinguish a sound from a murmur; occasionally, a sound may be confused with a murmur.

The perception of murmurs and of their qualities depends not only upon the examiner's ear, but upon the thickness, length, and state of the surface of the vascular opening through which the blood is circulating. Moreover, the thickness and the vibration of the chest should also be taken into consideration.

Sounds and murmurs are of great variety.

Heart sounds may resemble percussion-like sounds of a tom-tom drum, or they may have a sequence of a two-, three-, or four-beat rhythm (bigeminal, trigeminal, tetrageminal). A heart murmur can be blowing, rough, soft, machinery-like with coffee-mill noise, or have a musical component high or low in pitch. A careful auscultation of hearts might reveal to the examiner's ear a variety of characteristics of murmurs. Such an auscultation may even reveal the status of cardiac valves and arteries producing murmurs, and thus may help to distinguish, through listening alone, a rough surface from a smooth one, a calcified tissue from a fibrotic one. Indeed, the quality of a murmur depends upon the characteristics of the surface of the organs producing the particular murmur. The intensity of heart murmurs *is not always in proportion to the gravity of the disease:* a soft diastolic murmur may indicate a serious aortitis; a soft middiastolic apical murmur will indicate a serious mitral stenosis, in case of insufficiency, when a murmur becomes softer, the condition may become more serious. On the contrary, a loud systolic murmur in the pulmonic area or in the apical region, in youngsters or athletes, does not necessarily mean pathology Generally, it is easy to distinguish a sound from a murmur. The former is shorter than the latter

Difficulties arise in borderline cases when a murmur is short or a *sound is split* or prolonged. Occasionally, masking takes place when a murmur, lower in pitch or higher in intensity, overshadows a normal sound which is, therefore, no longer heard A low-intensity murmur can be masked by the normal heart sound Most difficult to hear are those of low intensity —high-pitched diastolic murmurs (see Fig. II).

A Few Words about Auscultation* (Fig. III)

For the examination of the apex, the observer is usually at the right side of the patient, who is lying slightly turned toward the left. In order to examine the base of the heart, the patient is seated, bending his chest forward.

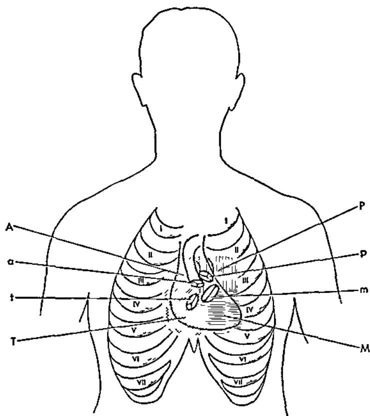
Auscultation of the heart can be practiced through direct application of the ear to the patient's chest (actually a handkerchief or a piece of fine linen, "serviette," is used), or mediately through a stethoscope or a stethophone of one kind or another. The large bell-like end of a stethoscope is used for low-pitched, high-intensity apical murmurs, and the diaphragm chest piece is used for the high-pitched basal murmurs. Whatever the method, the human ear never hears exactly the heart acoustics as they are produced within the heart, because of distortion, reflection, and refraction. On the other hand, whatever instruments are used for better listening (loudspeaker or even the usual stethoscope), these amplify and distort the sounds and the murmurs of the heart. Often the sounds and murmurs are not best heard at the cardiac areas, the procedure of "inching" (Samuel A. Levine, 1951) is then recommended. Occasionally, the acoustics of the heart are better heard following exertion (sitting up and lying down, or jumping a given number of times); before or after inspiration or expiration; or in sitting, erect, or recumbent position. Occasionally some sounds and murmurs are more easily heard in the back of the chest. Some observers hear better with closed eyes, concentrating first on each sound, then on each silence, and finally on murmurs when present.

Heart Valves (Fig. III)

There are four valves: at the apex, the mitral (m), and the tricuspid (t); at the base, the pulmonic (p), and the aortic (a). When the diameter, shape, form, and/or round smooth surface of these valves change, murmurs appear which may replace or accompany the normal heart sounds. When the valves become narrow, there is stenosis of the orifice; when the valve does not close completely, there is insufficiency of the valve. Incompetency may follow insufficiency; or both may coexist.† The characteristics of the murmur are the same, whether due to incompetency or insufficiency. Both stenosis and insufficiency often coexist Any abnormal opening, pressure,

* The following elementary details are intended for beginners only.

† The former is due to cardiac dilatation, whereas the latter is due to insufficient valvular closure



a	aortic valve	A	aortic area of auscultation
p	pulmonic valve	P	pulmonic area of auscultation
t	tricuspid valve	T	tricuspid area of auscultation
m	mitral valve	M	mitral area of auscultation

Roman numbers indicate the intercostal spaces **I, II, III, IV, V, VI, VII.**

Figure III. Cardiovascular valves and the respective areas of auscultation projected upon the chest

or narrowing of a vessel through which circulating blood is passing produces a murmur. Murmurs are systolic or diastolic, dependent on their appearance during the cardiac cycle. While most of the systolic murmurs are functional, majority of the diastolic murmurs are pathologic.

2. Cardio-Charting

THE SYMBOLS

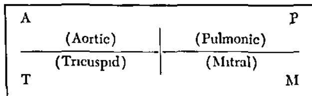
Suggestions for Arbitrary Rules for Direct Cardio-Charting

The heart sounds will be charted in blue, and the murmurs in red. When a rhythm is regular, it is sufficient to chart only one cardiac cycle. For demonstration purposes, however, all the illustrations show two cycles

Heart Sounds (Fig. IV) (Rather "bruits," since no definite pitch can be assigned to sounds)

1. Charting of Sounds. The sounds will be represented by vertical blue lines numbered 1, 2, 3, or 4 respectively.

2. Cardiac Areas. When it is desired to chart auscultatory findings originating from all the cardiac areas of maximum intensity, four individual spaces resulting from intersection of two lines, one vertical, the other horizontal, can be used.



Thus (facing the patient's chest), in the left lower quadrant are charted the findings pertaining to the mitral area (M), the upper left quadrant, the pulmonic area (P), the upper right quadrant, the aortic area (A), and the lower right quadrant, the tricuspid area (T).

Should only one cardiac region be of interest, then the diagram will cover the area to be considered For example, the mitral (M) area, for this purpose, the illustration will be limited only to a small area. Should two or three areas be described, then two or three distinct spaces will be reserved

for the illustration; thus, mitral (M) and aortic (A) or mitral (M) and pulmonic (P). Whatever the area is, it will always be defined by a corresponding letter: M, A, P, or T. The symbols of heart sounds and murmurs can be indiscriminately charted above or below an arbitrary horizontal line *which may be called the baseline* Thus, the chart above the baseline will show the findings over the base of the heart, while the symbols below the baseline will represent the findings of the apex.

3. ***Intercostal Spaces.*** These are indicated by Roman numerals, I, II, III, IV, etc.

4. ***Intensity.*** When a sound is loud, it will be represented by F (forte); very loud, FF; a soft sound, P (piano); and very soft, PP. The intensity of heart sounds depends on many factors: size, shape, and tonus of the heart; the age of the patient; size, shape, and content of the chest; speed and volume of blood circulating through the heart; etc. When the listening ear is *sufficiently trained, it is easy to distinguish between F, FF, P, and PP.* The accentuated sound is indicated by the letter F, i.e., the first accentuated heart sound over the apex in mitral stenosis.

5. ***Duration.*** The duration of sounds is proportionate to the width of the blue lines. The broader the line, the longer the sound lasts.

6. ***Pitch.*** The pitch is inversely proportionate to the height of the lines. The taller the line, the lower the pitch, and inversely.

It is useful to think of the piano or the organ, where the longer the strings, or the higher the pipes, the lower the tones produced.

7. ***Rate (Pulse).*** All diagrams will show at the top the heart rate: thus, 60, 70, 80, etc., per minute. Babies have a faster pulse than adults. Generally the larger the heart, the slower the pulse rate; an elephant and a whale have a rate of 16 to 20 per minute, while some birds have a rate of over 200 per minute.

Rhythms. The rhythm is a succession of sounds recurring periodically with the same cadence within one or more cycles. Regular sinus rhythm is illustrated in Figure XI (1947). Two blue lines, numbered 1 and 2, represent the first and the second heart sounds, the first blue line represents a sound lower in pitch and lasting longer than the second sound, therefore, *the first* blue line is taller and broader than the second line. M indicates the mitral valve (apical region), V, fifth interspace, and 72, pulse rate The first heart sound is followed by a shorter silence than the second heart sound

Bradycardia takes place when the heart rate is below 50 per minute.

Tachycardia is present when the rate is over 100 per minute.

Tick-tack rhythm is present when the two sounds are separated by even pauses—clock's ticking.

1. Charting of heart sounds
2. Cardiac areas
3. Intercostal spaces
4. Intensity (loudness)
5. Duration
6. Pitch
7. Rate (pulse)

RHYTHMS (8-13)

8. Split sounds split first sound, split second sound
9. Presystolic gallop rhythm
10. Systolic gallop rhythm
11. Protodiastolic gallop rhythm
12. Atrial extrasystole
13. Ventricular extrasystole
14. Pericardial friction rub (presystolic, mesodiastolic, systolic)

Figure IV. Key to charting heart sounds and their rhythms.

Intrauterine Fetal Heartbeats. The first heart sound usually lasts longer and is lower in pitch than the second heart sound which is more intense. The *second silence is longer than the first one. This is not a tick-tack rhythm,* but rather a tachycardia.

Sinus arrhythmia is mostly due to respiration. The heart rate becomes slower during inspiration and faster during expiration.

Bigeminal Rhythm. The second sound of the bigeminal rhythm is an extrasystole. (Two cycles are to be charted.)

Trigeminal Rhythm. The third sound (as well as the second) is an extrasystole. (Three cycles are to be charted.)

Reduplication of Sounds (Split Sounds). The reduplication is a split of a normal heart sound into two even components (often heard in healthy individuals) during extrasystoles and in bundle branch block. The reduplication will be represented by a double vertical blue line corresponding to a single blue line of a normal heart sound.

8. Reduplication of the first heart sound is best heard at the fifth left interspace (V), at the end of inspiration or at the beginning of expiration (Potain). It is mostly due to the asynchronic closure of the mitral and the tricuspid valves, the patient being in the erect position.

Reduplication of the Second Heart Sound. This reduplication is more frequent than the previous one and is best heard at the base of the heart. It is mostly due to asynchronic closure of the aortic and pulmonic valves (normally the aortic valve closes before the pulmonic)—"cri de la caille," "rappel du tambour," "choc du marteau retombant sur l'enclume."

While the reduplication of the first heart sound has always the same duration as the first sound itself (nonsplit), the reduplication of the second sound usually lasts longer than the same nonsplit sound. While reduplication of the first sound is heard in bundle branch block, and reduplication of the second sound in mitral stenosis, these reduplications are not characteristic or specific of a given cardiopathy.

The gallop rhythm ("bruit de gallop," Bouillaud, 1847) is characterized by three distinct sounds, two physiologic and one pathologic (G). It is a tripling of the heart rhythm with a sound of a canter ("horse's gallop on a stone road"), and is mostly a sign of myocardial involvement. Wherever it takes place, the additional sound of the gallop rhythm will be indicated by the letter G.

9. Presystolic Gallop (Atrial). The additional sound with the letter G precedes the blue line numbered 1 (first heart sound) This gallop rhythm is often heard in bundle branch block.

10. Systolic gallop, questionable by some authors, is best heard at the apex, with the patient in a recumbent position. The additional sound (gallop, G) is represented by a blue line which follows the first blue line that is numbered 1 (first heart sound).

11. Protodiastolic Gallop (Mesodiastolic). In healthy individuals this gallop is very difficult to distinguish from the physiologic third heart sound The additional G line that represents the gallop rhythm is placed here after the blue line numbered 2 (second heart sound). Some authors distinguish a pulmonic and a protodiastolic gallop over the base of the heart.

Summation gallop occurs when both the protodiastolic and the presystolic gallops are combined, which takes place during marked tachycardia.

Arrhythmias

Extrasystoles. These are atrial and ventricular (more common) and are indicated by the letter X.

12. *Atrial extrasystole* is followed by a longer pause than normally but which is not compensatory, and is charted with the letter X, placed above the blue line

13. *Ventricular extrasystole* is followed by a longer pause than normally, which is fully compensatory, and the X is placed below the blue line.

Atrial Flutter. In this arrhythmia the atria contract at the rate of 200 per minute or more, which is represented by a fraction—the numerator of which is 200, and its denominator indicates the ventricular or pulse rate, for example, 200/100. (Fig. XI, 1951.)

Atrial Fibrillation. The artia and ventricles contract unevenly, and the atria beat at a rate of over 400 per minute This arrhythmia is also represented by a fraction—the numerator of which is 400, and the denominator indicates the pulse rate, for example, 400/64 (Fig. XI, 1952.)

Paroxysmal Atrial Tachycardia This is a rapid succession of atrial extrasystoles and is charted by a corresponding number of blue lines, each of them indicated by the letter X (above the line).

Multiple Ventricular Extrasystoles ("extrasystoles en salves"). This is a succession of ventricular extrasystoles that are charted by a corresponding number of blue lines, each indicated by the letter X (below the line).

Heart blocks—sinoatrial, atrioventricular (partial or complete), and bundle branch blocks—are charted in accordance with their rates and rhythms, just as they are perceived by the examining ear.

14. Pericardial Friction Rub. This is a rough grating or shuffling sound ("papier de soie," "cuir neuf," "râclement"), occurring irregularly with no relationship to the cardiac cycle (only difference with heart murmurs). It is best heard where the pericardium is near the chest wall, not covered by the lungs, in the third or fourth left interspace. The friction rub usually appears during the systolic or diastolic pause, and is often irregular and variable. It is sometimes described as a presystolic, mesodiastolic, or systolic rub. It becomes inaudible when the breath is held. The rub will be charted as small red dots placed between the blue lines representing the heart sounds.

Heart Murmurs (Fig. V)

1. Charting of Murmurs. Murmurs are charted with red symbols. Thus their presence is revealed at once. Occasionally the shape of the symbol helps to visualize the dynamics of a murmur: thus, a continuous symbol, an even symbol, a diamond-shaped symbol.

2-3. Location within the Cardiac Cycle. Depending on their appearance within the cardiac cycle, the murmurs may be: presystolic, mid- (meso-) systolic, late (tele-) systolic, postsystolic, holosystolic, or in short *systolic (2)*, or *diastolic (3)*. Systolic means that the red symbol is placed between the blue lines representing the first and the second sound; diastolic, that the red marking will occupy a part or the entire space between the second sound and the first sound of the next cardiac cycle. The space occupied by the red color is in proportion to the duration of the murmur; the broader the red symbol, the longer the murmur lasts.

Organic or Functional. The question often arises whether a murmur is organic or functional, and it is not always easy to answer with certainty. However, when a murmur is loud and persists for a long time, without changing in character, there is a strong suspicion that this murmur is organic and will be revealed in the chart by the constant red symbol. The Cardio-Chart illustrates the murmurs, organic or functional, which were heard during the examination. However, when a functional murmur is present, a single red outline will represent it, instead of the full red symbol used for organic murmurs (Fig XI, 1948).

4. Intensity. As for the sounds—FF, very loud, F, loud, P, soft; and PP, very soft. The only accepted and used formula for charting murmurs in the United States is the graduation of the intensity. Thus, murmurs are charted in accordance with the apparent loudness, as grade I to grade VI (Samuel A Levine, 1951) However, what is grade I for one examiner may be grade II, III, or IV for another examiner, and vice versa.

1. Charting of murmurs

2. Systolic murmur

3. Diastolic murmur

4. Intensity (loudness)

NUANCES (5-6)

5. Crescendo

6. Decrescendo (diminuendo)

QUALITY (7-10)

7. Rough murmur

8. Soft murmur

9. Musical, high-pitched murmur

10. Musical, low-pitched murmur

11. Radiation

12. Position of patient

13. Predominant murmur

14. Masking of a sound

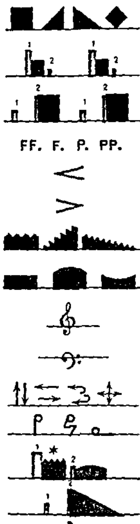


Figure V Key to charting heart murmurs and their characteristics.

Dynamics. Besides the above-mentioned intensity, the murmurs may present different shadings, especially when the intensity or loudness changes; they may increase or decrease.

5. Crescendo (increase in intensity): <

6. Decrescendo (decrease in intensity): >

First increasing, then decreasing, diamond-shaped murmur: <>

Occasionally a murmur starts loudly, decreases, and becomes loud again, or is wave-like. <><

7-10. Quality. A murmur can be rough (7), or soft (8). The shape of the symbol representing the murmur indicates the quality. When the murmur is rough, it is charted by a red dented symbol; a soft murmur is indicated by a symbol having a smooth, even surface.

Pitch is the level—high or low—of a sound or a murmur, and depends on the diameter and the length of the opening through which the blood is circulating; the larger the opening, the lower the pitch. The pitch is determined by the frequency of vibrations per second; the higher the number (cycles per second), the higher the pitch Often a heart murmur has a musical component, high or low in pitch. It is easy to differentiate one from the other. A woman's voice is high in pitch (soprano), and a man's voice is low in pitch (bass). A large patent ductus arteriosus produces a low-pitched murmur, whereas a patent ductus arteriosus with a narrow lumen produces a high-pitched murmur. A murmur having a musical component high in pitch is indicated by the treble clef 𝄞 (9), and a murmur having a musical component low in pitch is indicated by the bass clef 𝄢 (10).

11. Radiation is the transmission of murmurs and is indicated by an arrow pointing toward the given direction. The direction is not necessarily the one that follows the blood stream. The symbol that represents the radiation points: upward, downward, to the right, to the left, to the back, to the front, centrifugally.

12. Position of the Patient during Examination. Often some murmurs are better heard when the patient is in a given position, which is indicated and will be recognized by a corresponding symbol—vertical, bent, or horizontal (Position: erect, seated, or recumbent.)

13. Predominant Murmurs. In presence of two or more murmurs, the predominant murmur is indicated by an asterisk (*). It is very important to recognize the predominant murmur when several are present, particularly when cardiovascular surgery is considered.

14. Masking of Sounds. When a murmur is lower in pitch, or higher in intensity than a sound, the latter becomes inaudible, and masking takes place. The masked one, as well as any sound which becomes inaudible, is represented by a blue disk placed beneath the baseline (instead of the blue line) (Fig. X, e, and Fig. XI, 1936).

Often a murmur is better heard during inspiration, and the symbol is (Fig. XI, 1932), or expiration (Fig. IX, a and c).

Should a murmur be better heard following exertion, the symbol is charted (Fig. XI, 1949).

PART II

3. Technique; Systolic and Diastolic Murmurs; Congenital Cardiopathies

TECHNIQUE

In order to chart details of cardiac auscultation correctly and completely it is important to know first where, on the precordium, was maximum audibility, and, then, what actually was perceived by the examining ear.

Where Should We Listen?

Among the four different cardiac areas there is usually one which is of particular interest to the physician; it is the region where a given murmur is best heard. Therefore, charting should start with the indication of this region which is the center of the observer's attention. This is the auscultatory cardiac area—M (mitral), P (pulmonic), A (aortic), or T (tricuspid) (Fig. III). For greater precision the intercostal region is also indicated, alongside the initial representing the cardiac area, by Roman figures, I, II, III, IV, V, VI, etc.

What to Hear?

Heart sounds with their rates and rhythms, split sounds, extrasystoles, gallop rhythms, flutter or fibrillation, and any particularity pertaining to sounds are charted in *blue.*

Heart murmurs with their characteristics, whether congenital or acquired, organic or functional, systolic or diastolic, rough or soft, high- or low-pitched, and any particularity pertaining to murmurs are charted in *red.*

Universality

The colored symbols can be placed side by side in any direction from left to right, for occidental countries, from right to left, for Middle East countries, and vertically, for Far East countries.

SYSTOLIC AND DIASTOLIC MURMURS AND THEIR SYMBOLIC PRESENTATION*

Instead of a description of systolic and diastolic murmurs, and also because of their infinite variety, a short review of pathologic conditions is presented. In the illustrations, the murmurs correspond to the clinical diagnosis.

Mitral Valvular Lesions

Mitral Stenosis (MS) (Fig VI A, 1). The picture shows a red dented area with a crescendo symbol (presystolic murmur), followed by a blue line numbered 1 and the letter F, then two parallel blue lines (accentuated first heart sound and split second sound), and, finally, a blue line numbered 3† (opening snap of the mitral valve) The auscultation takes place in the mitral region, fifth interspace, the pulse beats 60 per minute, and the patient is in a recumbent position.

Mitral stenosis is one of the most common valvular lesions caused by rheumatic fever The auscultation may reveal a low-pitched middiastolic crescendo murmur best heard at the apex. During atrial fibrillation, this murmur may disappear. The characteristics of this crescendo murmur are determined by the degree of the stricture and the rate of the blood circulating through the narrowed valve. Occasionally this murmur is represented by two components. a protodiastolic rumbling followed by a presystolic murmur The murmur begins softly and gradually becomes louder (crescendo), terminating with a snapping, accentuated first heart sound This accentuated sound is loud, tympanic, and bell-like, and is due to the stretching of the mitral valve and to the noise produced by the insufficiently filled left ventricle. "empty barrels make the most noise" A reduplication or

* The physiopathologic details, which follow and which are responsible for the production of some cardiac murmurs, are here intentionally mentioned in order to produce in the mind of the reader the pattern of the colored corresponding symbols that he

of the mitral valve is heard only in mitral stenosis

splitting of the second sound is heard over the base, most probably due to the asynchronic closure of the pulmonic and aortic valves.

In mitral stenosis an additional heart sound is often heard in the fourth interspace, halfway between the apex and the left sternal border. It appears about 0.1 second after the second sound and originates from the sudden tension of the stenotic mitral valve at the beginning of the diastole: "claquement d'ouverture de la mitrale." This snap is diagnostic of mitral stenosis The rumbling presystolic murmur (the protodiastolic and the presystolic components), the reduplication of the second sound, and the opening snap of the mitral valve constitute the "onomatopée" of Durozier: "rouff-ffout-tata-tac." In cases of tight mitral stenosis only a systolic apical murmur may be heard. Presystolic murmurs are heard in a variety of anemias. Occasionally a presystolic apical murmur is heard over the apex even though its origin is within the aortic area, this murmur is due to *aortic insufficiency (Austin Flint murmur).*

Mitral Insufficiency (MI) (Fig. VI A, 2). The picture shows a blue vertical line numbered 1 (first sound), followed by a red shading with an arrow pointing outward and upward (soft systolic murmur radiating toward the left axilla), then a blue line numbered 2 (second sound). The patient is in a recumbent position, and the pulse is 60 per minute.

Mitral insufficiency is characterized by a loud, harsh, high-pitched, occasionally musical systolic murmur, best heard at the apex, radiating toward the left axilla. Its quality depends on the velocity of the blood flow and the degree of insufficiency of the dilated valve. One half of systolic apical murmurs is functional, often heard in youngsters, or following exertion. Sometimes a systolic apical murmur is also heard during fever, anemia, or hyperthyroidism, and the murmur disappears with the disappearance of the abnormal condition. A sudden appearance of a blowing systolic apical murmur may be due to a ruptured valve or to an acute dilatation of the heart. In chronic dilatation, with a loud booming heart, the murmur may disappear because of heart failure

Mitral stenosis and mitral insufficiency (MS and MI) (Fig. VI A, 3) ("maladie mitrale") constitute a combined valvular disease. The content of the two previous pictures are here combined in one: red symbol with dented surface, followed by a blue line, another red symbol with an arrow, a double blue line, and, finally, a blue line numbered 3 (presystolic crescendo murmur, accentuated first heart sound, systolic murmur radiating upward, toward the left axilla, followed by the split second sound, and the opening snap of the mitral valve).

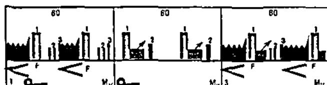


Figure VI A. *Mitral murmurs*

1. Blue symbols 1, first sound, 2, split second sound, 3, the opening snap of the
st part
ystolic
pulse

2 Blue symbols 1, first sound, 2, second sound Red symbol with an arrow pointing upward and outward—*systolic murmur* (the red symbol follows the first sound). Such a murmur occurs in *mitral insufficiency*

3 The above paragraphs (numbered 1 and 2) are here combined, *presystolic* and *systolic* apical *murmurs* *mitral stenosis* and *mitral insufficiency* ("maladie mitrale").

splitting of the second sound is heard over the base, most probably due to the asynchronic closure of the pulmonic and aortic valves.

In mitral stenosis an additional heart sound is often heard in the fourth interspace, halfway between the apex and the left sternal border. It appears about 0.1 second after the second sound and originates from the sudden tension of the stenotic mitral valve at the beginning of the diastole: "claquement d'ouverture de la mitrale." This snap is diagnostic of mitral stenosis. The rumbling presystolic murmur (the protodiastolic and the presystolic components), the reduplication of the second sound, and the opening snap of the mitral valve constitute the "onomatopée" of Duroziez: "rouff-ffout-tata-tac." In cases of tight mitral stenosis only a systolic apical murmur may be heard. Presystolic murmurs are heard in a variety of anemias Occasionally a presystolic apical murmur is heard over the apex even though its origin is within the aortic area; this murmur is due to aortic insufficiency (Austin Flint murmur).

Mitral Insufficiency (MI) (Fig. VI A, 2). The picture shows a blue vertical line numbered 1 (first sound), followed by a red shading with an arrow pointing outward and upward (soft systolic murmur radiating toward the left axilla), then a blue line numbered 2 (second sound). The patient is in a recumbent position, and the pulse is 60 per minute.

Mitral insufficiency is characterized by a loud, harsh, high-pitched, occasionally musical systolic murmur, best heard at the apex, radiating toward the left axilla Its quality depends on the velocity of the blood flow and the degree of insufficiency of the dilated valve. One half of systolic apical murmurs is functional, often heard in youngsters, or following exertion. Sometimes a systolic apical murmur is also heard during fever, anemia, or hyperthyroidism, and the murmur disappears with the disappearance of the abnormal condition. A sudden appearance of a blowing systolic apical murmur may be due to a ruptured valve or to an acute dilatation of the heart. In chronic dilatation, with a loud booming heart, the murmur may disappear because of heart failure

Mitral stenosis and mitral insufficiency (MS and MI) (Fig VI A, 3) ("maladie mitrale") constitute a combined valvular disease. The content of the two previous pictures are here combined in one: red symbol with dented surface, followed by a blue line, another red symbol with an arrow, a double blue line, and, finally, a blue line numbered 3 (presystolic crescendo murmur, accentuated first heart sound, systolic murmur radiating upward, toward the left axilla, followed by the split second sound, and the opening snap of the mitral valve).

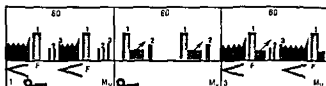


Figure VI A. *Mitral murmurs*

1. Blue symbols 1, first sound, 2, split second sound, 3, the opening snap of the mitral valve (this is not the third physiologic heart sound) Red symbol: the first part of this symbol—*middiastolic rumbling*, the end of the symbol—*crescendo presystolic murmur* The patient is lying on the left side M_V—mitral area, fifth interspace, pulse rate is 60 per minute. These are characteristics noted in *mitral stenosis*

2 Blue symbols 1, first sound, 2, second sound. Red symbol with an arrow pointing upward and outward—*systolic murmur* (the red symbol follows the first sound). Such a murmur occurs in *mitral insufficiency.*

3. The above paragraphs (numbered 1 and 2) are here combined, *presystolic* and *systolic* apical *murmurs* *mitral stenosis* and *mitral insufficiency* ("maladie mitrale").

Aortic Valvular Lesions

Aortic Stenosis (AS) (Fig. VI B, 1). The picture shows a small blue *line numbered 1 (first sound), followed by a diamond-shaped red symbol* with a dented surface and two arrows, and the letter F (rough, loud crescendo-decrescendo* systolic aortic murmur, radiating upward toward the neck vessels and downward toward the apex); then, a thin blue line numbered 2 (second sound). Auscultation is best performed in the second or third interspace, near the sternum, and the pulse is 60 per minute. Aortic stenosis may be acquired or congenital and is characterized by a loud, harsh, rough, ringing systolic murmur. When immediate auscultation is practiced, a thrill may be felt at the same time that the murmur is heard. Often the second aortic sound is diminished in intensity or even absent. A calcified and narrowed aorta (medial arterial Monckeberg's sclerosis) produces a loud, harsh, middiastolic murmur.

Aortic Insufficiency (AI) (Fig. VI B, 2). First, the picture shows a small blue line numbered 1, then a taller blue line numbered 2, with the letter P (first and second sounds, the latter soft); a red shading with three arrows and a decrescendo symbol (diastolic aortic murmur, decrescendo, radiating in three directions, toward the neck, the axilla, and the apex). The red bent symbol (bottom, left) indicates that the murmur was best heard when patient was seated. Pulse was beating at the rate of 60 per minute.

Rheumatic, syphilitic, hypertensive, or sclerotic aortitis may be characterized by a soft diastolic murmur, which is blowing, gushing, high-pitched, of low intensity, decrescendo, and occasionally musical (sea gull, mewing, cooing). The murmur is not separated from the second sound, and is best heard over the aortic area, at the third-fourth interspace, near the left sternal border, with the patient in a sitting position, and at the end of expiration. The diastolic murmur is radiating upward toward the neck vessels (for some writers toward the left axilla and also downward). It is often accompanied by a systolic murmur at the apex. Occasionally, when this diastolic murmur is transmitted toward the apex, it is called an "hourglass murmur" ("souffle en cravate"), and it will be recognized by an arrow pointing downward and to the left.

Aortic Stenosis and Aortic Insufficiency (AS and AI) (Fig. VI B, 3). The two above-mentioned murmurs are here combined in one picture: a small blue line numbered 1, a diamond-shaped red shading, with two arrows, a tall blue line numbered 2 and followed by another red shading with three arrows and a decrescendo symbol (first sound, rough systolic

* The outline of the red symbol shows the crescendo-decrescendo nuances.

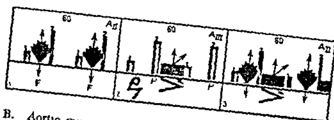


Figure VI B. *Aortic murmurs*

1. Blue symbols 1, first sound, 2, second sound Red symbol, diamond-shaped, with two arrows pointing upward and downward—*systolic murmur* A_{II}—aortic area, second right interspace In this frame, the symbol represents *aortic stenosis*

2 Red symbol (decrescendo, patient seated), following immediately the second sound, indicates the presence of a *diastolic murmur* of *aortic insufficiency*

3. The above paragraphs (numbered 1 and 2) are here combined, *systolic* and *diastolic murmurs* *aortic stenosis* and *aortic insufficiency*.

Aortic Valvular Lesions

Aortic Stenosis (AS) (Fig. VI B, 1). The picture shows a small blue line numbered 1 (first sound), followed by a diamond-shaped red symbol with a dented surface and two arrows, and the letter F (rough, loud crescendo-decrescendo* systolic aortic murmur, radiating upward toward the neck vessels and downward toward the apex); then, a thin blue line numbered 2 (second sound). Auscultation is best performed in the second or third interspace, near the sternum, and the pulse is 60 per minute. Aortic stenosis may be acquired or congenital and is characterized by a loud, harsh, rough, ringing systolic murmur. When immediate auscultation is practiced, a thrill may be felt at the same time that the murmur is heard. Often the second aortic sound is diminished in intensity or even absent. A calcified and narrowed aorta (medial arterial Monckeberg's sclerosis) produces a loud, harsh, middiastolic murmur.

Aortic Insufficiency (AI) (Fig. VI B, 2). First, the picture shows a small blue line numbered 1, then a taller blue line numbered 2, with the letter P (first and second sounds, the latter soft); a red shading with three arrows and a decrescendo symbol (diastolic aortic murmur, decrescendo, radiating in three directions, toward the neck, the axilla, and the apex). The red bent symbol (bottom, left) indicates that the murmur was best heard when patient was seated Pulse was beating at the rate of 60 per minute.

Rheumatic, syphilitic, hypertensive, or sclerotic aortitis may be characterized by a soft diastolic murmur, which is blowing, gushing, high-pitched, of low intensity, decrescendo, and occasionally musical (sea gull, mewing, cooing). The murmur is not separated from the second sound, and is best heard over the aortic area, at the third-fourth interspace, near the left sternal border, with the patient in a sitting position, and at the end of expiration The diastolic murmur is radiating upward toward the neck vessels (for some writers toward the left axilla and also downward). It is often accompanied by a systolic murmur at the apex. Occasionally, when this diastolic murmur is transmitted toward the apex, it is called an "hourglass murmur" ("souffle en cravate"), and it will be recognized by an arrow pointing downward and to the left

Aortic Stenosis and Aortic Insufficiency (AS and AI) (Fig. VI B, 3). The two above-mentioned murmurs are here combined in one picture: a small blue line numbered 1, a diamond-shaped red shading, with two arrows, a tall blue line numbered 2 and followed by another red shading with three arrows and a decrescendo symbol (first sound, rough systolic

* The outline of the red symbol shows the crescendo-decrescendo nuances.

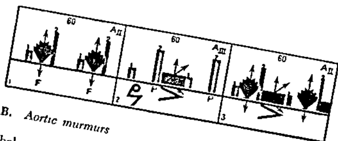


Figure VI B. *Aortic murmurs*

1. Blue symbols 1, first sound, 2, second sound Red symbol diamond-shaped, with two arrows pointing upward and downward—*systolic murmur* A_{II}—aortic area, second right interspace In this frame, the symbol represents *aortic stenosis*

2. Red symbol (decrescendo, patient seated), following immediately the second sound, indicates the presence of a *diastolic murmur* of *aortic insufficiency*

3 The above paragraphs (numbered 1 and 2) are here combined, *systolic* and *diastolic murmurs aortic stenosis* and *aortic insufficiency*

aortic murmur, second sound, a diastolic decrescendo aortic murmur *radiating in three directions)*. The murmurs are best heard over the aortic area, and the pulse is 60 per minute. When the two murmurs described are heard over the aortic area, it gives a to-and-fro impression ("bruit de va-et-vient").

Tricuspid Valvular Lesions

Tricuspid Stenosis (TS) (Fig. VII A, 1). The picture shows a red dented symbol, a blue line numbered 1, followed by a double blue line numbered 2 (presystolic tricuspid murmur, first sound, split second sound).

Tricuspid stenosis is rare and, if present, is generally associated with tricuspid insufficiency or a mitral or an aortic lesion. It is characterized by a middiastolic or a late diastolic murmur *difficult to distinguish from* that of mitral stenosis. The murmur, when present, is best heard over the lower half of the sternum, near its left border. About 25 per cent of mitral lesions are associated with tricuspid stenosis, but the latter is rarely clinically demonstrable.

Tricuspid Insufficiency (TI) (Fig. VII A, 2). First the picture shows a *blue line numbered 1, followed by a red smooth symbol with the letter F,* and, finally, a blue line numbered 2 (first sound, a loud blowing systolic murmur, and the second sound).

Tricuspid insufficiency is rarely a single lesion; it is mostly associated with a mitral or aortic stenosis or insufficiency. It is very difficult to hear a murmur of isolated (pure) tricuspid insufficiency. Usually this condition is characterized by a prolonged blowing systolic murmur, which is best heard at the lower part of the sternum, near the xiphoid process, during inspiration Should this murmur of tricuspid insufficiency appear in the presence of aortic insufficiency, the latter murmur (of AI) may become inaudible.

Tricuspid Stenosis and Tricuspid Insufficiency (TS and TI) (Fig. VII A, 3). The picture shows both the above-mentioned murmurs: a red dented symbol, a blue line numbered 1, a red symbol with a smooth surface, a double blue line numbered 2 (presystolic rough murmur, first sound, soft systolic murmur, a split second sound). These murmurs are best heard over the tricuspid region. The pulse is 60 per minute.

This combined lesion gives the audible sensation of a systodiastolic murmur, similar to the one heard in mitral stenosis and mitral insufficiency.

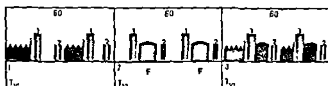


Figure VII A. *Tricuspid murmurs*

1. Red symbol follows the second sound and indicates a *diastolic murmur* of *tricuspid stenosis*

2 Blue symbols, 1, first sound, 2, second sound T_{VI}—tricuspid area, sixth interspace Red symbol follows the first sound and indicates a *systolic murmur*. In this frame, the red symbol represents *tricuspid insufficiency*

3 The above paragraphs (numbered 1 and 2) are here combined, *diastolic* and *systolic murmurs tricuspid stenosis* and *tricuspid insufficiency*

Pulmonic Valvular Lesions

Pulmonary Stenosis (PS) (Fig. VII B, 1). The picture shows a small blue line numbered 1, a red dented symbol with two arrows pointing *in two opposite directions and with the letter F* (first sound, a loud, rough systolic murmur, radiating upward and downward, followed by the second sound). The murmur is best heard over the pulmonic area. The pulse is 60 per minute.

Pulmonary stenosis may be acquired or congenital and is generally accompanied by other lesions of the heart. There is a loud, rough systolic murmur at the base, near the second left interspace. Usually a diastolic murmur is also heard in the same region. Often the second sound in this area is attenuated or is completely inaudible (masked). This valvular lesion is also characterized by a systolic thrill which can be felt together in synchrony with the murmur, when direct (immediate) auscultation is practiced. Some examiners state that they can discriminate an infundibular from a valvular murmur in pulmonary stenosis, merely by placing the stethoscope higher or lower.

Pulmonary Insufficiency (PI) (Fig. VII B, 2). The picture shows two blue lines, numbered 1 and 2, a red symbol with a smooth surface and a decrescendo symbol (first and second sounds, the latter followed immediately by a soft, diastolic, decrescendo pulmonic murmur).

Pulmonic insufficiency is a rare condition and, when present, is characterized by a soft, high-pitched, diastolic murmur of "high pressure." It is best heard at the second–third interspace near the left sternal border. Often a systolic murmur may also be heard, which is due to the coexistence of a pulmonic stenosis. When a diastolic murmur is heard over the pulmonic area concurrent with a presystolic murmur over the apex, it is called Graham Steell murmur.

Pulmonary Stenosis and Pulmonary Insufficiency (PS and PI) (Fig. VII B, 3). *The picture shows the presence of both murmurs described above: a blue line, a red dented symbol with two arrows, a second blue line with* the letter P, a red smooth symbol with a decrescendo symbol (first sound, loud rough systolic murmur, soft second sound, soft decrescendo pulmonic diastolic murmur) These murmurs are best heard over the pulmonic area. The pulse is 60 per minute

When pulmonary stenosis and pulmonary insufficiency coexist, the heart sounds usually become inaudible (masked).

All the characteristics of different valvular lesions can be easily charted with the red–blue symbols and instantly recognized

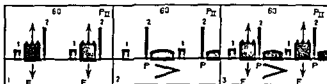


Figure VII B *Pulmonary murmurs*

1. Blue symbols: 1, first sound, 2 (taller line than 1), second sound (the second sound is better heard over the base than over the apex) P_{II}—pulmonary area, second interspace, the pulse is 60 per minute. Red symbol follows the first sound and indicates a *systolic murmur* that is heard in *pulmonary stenosis*

2 Red symbol follows the second sound and may be described as a decrescendo *diastolic murmur* that is heard in *pulmonary insufficiency*

3. The above paragraphs (numbered 1 and 2) are here combined, *systolic* and *diastolic murmurs* *pulmonary stenosis* and *pulmonary insufficiency*

CONGENITAL CARDIOPATHIES* (CARDIOVASCULAR LESIONS AND THEIR SYMBOLIC PRESENTATION)
(Fig VIII)

Coarctation of the Aorta (1). The picture shows a red dented symbol between the two blue lines, and the red symbol contains a curved arrow (first and second sounds, the latter is occasionally inaudible, a rough systolic aortic murmur radiating toward the neck vessels and toward the back). The greatest intensity of the murmur is in the aortic area, in the second interspace near the sternum. The pulse is 72 per minute.

Interatrial Septal Defect (2). The picture shows a small blue line *numbered 1, followed by a red symbol with a smooth surface and two* horizontal arrows and the letter F, a taller blue line numbered 2, with the letter F (first and second sounds, a loud blowing systolic midcardiac murmur radiating toward left and right sides). Maximum intensity is heard over the upper third of the sternum, in the pulmonic area, second left interspace. The pulse is 64 per minute. Occasionally a diastolic murmur may also be heard, and usually the second heart sound is accentuated.

Lutembacher's Syndrome (3). The picture illustrates two areas: below the baseline, the mitral; and above the baseline, the pulmonic. In the mitral area there is a red dented shading with a crescendo symbol that is followed by blue lines numbered 1, 2, 3 (presystolic apical murmur, first and second sounds, and opening snap of the mitral valve). Over the baseline there is a small blue line numbered 1, followed by a red symbol with a smooth surface, and a double blue line numbered 2 (first and second sounds, the latter split, and a soft systolic midcardiac murmur).

Interventricular Septal Defect (4). The picture shows a small blue line numbered 1, followed by a red dented symbol with four arrows pointing in different directions and the letters FF, this is followed by a narrow space numbered 2, under which is placed a blue disk (first sound, a rough, very loud systolic murmur radiating in all directions, like the spokes of a wheel, masking the second heart sound)

This congenital cardiopathy ("maladie de Roger") is characterized by a loud, harsh, prolonged systolic murmur heard over the entire precordium. This murmur is mostly extended over the systolic pause and occupies a part of the diastole, it is best heard between the second–fourth left interspace, near the sternum, and it radiates in all directions ("en roue")

* The congenital cardiopathies mentioned herein are not presented in their usual order of frequency.

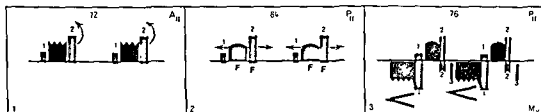


Figure VIII (1-3). Some congenital cardiovascular lesions

1. *Coarctation of the aorta* is characterized by a *systolic murmur*—red symbol following the first blue line, radiating toward the back (arrow), and is best heard over the aortic area, second interspace, near the sternum.

2 *Interatrial septal defect* is indicated by a *systolic murmur*—red symbol following the first blue line, and is best heard over the pulmonic area, second interspace

3 *Lutembacher's syndrome* is characterized by a middiastolic rumbling that is followed by a *presystolic, crescendo murmur*—red dented symbol preceding the first blue line, terminating with an accentuated *first* sound over the *apex* (M). Over the base (P_{II}), a split of the second sound (2) is indicated, preceded by a systolic murmur (red symbol, smooth surface) due to the interatrial persistent septal defect and opening snap of the mitral valve (3) which should not be confused with the third heart sound. *interatrial septal defect* and *mitral stenosis*

Tetralogy of Fallot (5). Because the murmurs are heard throughout the entire precordium, the picture presents all four cardiac areas. The blue lines that are numbered 1 and 2 represent the first and the second heart sounds; however, the blue line numbered 1 is longer below the baseline, while the one numbered 2 is taller above the baseline. This is due to the fact, which is well known, that normally the first heart sound is better heard over the apex, while the second heart sound is better heard over the base of the heart. Between these two blue lines numbered 1 and 2, a red dented symbol is present, but this symbol over the mitral region is characterized by only one F, whereas the same symbol over the pulmonic area is marked with a double F (FF) and an asterisk. (A rough, loud systolic murmur is heard over the entire precordium: in the mitral, pulmonic, aortic, and tricuspid regions, and its intensity is the greatest over the pulmonic area, where the murmur is predominant.)

Tetralogy of Fallot is characterized by four abnormalities: interventricular septal defect, pulmonary stenosis, enlargement of the right ventricle, and dextroposition of the aorta. It is evident that the very loud, rough murmur heard throughout the precordium is due to many factors and that each component has a different origin.

***Eisenmenger's Complex* (6).** The picture shows a blue line numbered 1, a red dented symbol with two arrows, a tall blue line numbered 2, followed immediately by a red shading with a decrescendo symbol and an arrow pointing downward and outward, the precordial region examined is the pulmonic area in the second interspace (first sound, rough systolic murmur, radiating toward the left and the right, second sound, immediately followed by a decrescendo symbol, diastolic pulmonic murmur, radiating downward and outward).

This congenital cardiopathy is also characterized by four abnormalities: interventricular septal defect, pulmonary insufficiency (this is the only difference between the tetralogy of Fallot and Eisenmenger's complex), enlargement of the right ventricle, and dextroposition of the aorta. A loud systolic murmur in the midcardiac region is occasionally accompanied by a pulmonic diastolic component. It is not easy to hear each individual murmur in the presence of two or more murmurs, particularly when they do not originate from the same focus

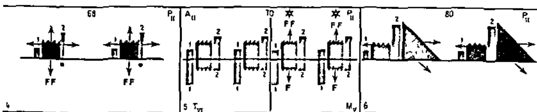


Figure VIII (4-6) Some congenital cardiovascular lesions (cont).

4 *Interventricular septal defect* is here illustrated by a *systolic midcardiac murmur*—red dented symbol, radiating in all directions; it is best heard over the pulmonic area. The second sound is masked (blue disk)

5 *Tetralogy of Fallot* is characterized by a *loud, rough systolic murmur* (heard over the entire precordium), and is illustrated here by a red dented symbol, all four cardiac areas are represented in the frame The predominant murmur is best heard over the pulmonic area (asterisk).

6 [illegible] The red dented symbol following the first sound (1) [illegible] defect. The red decres- [illegible] *tolic murmur* that is due [illegible]

Patent Ductus Arteriosus (Fig X, a and c). Following the first blue line (first sound) there is a continuous red symbol, reaching the second blue line and then coming down to the first blue line of the next cardiac cycle (continuous rough, machinery-like murmur, best heard over the pulmonic area, while the patient is seated).

Patent ductus arteriosus is one of the most common congenital lesions and is characterized in early stages only by a systolic murmur which is best heard over the pulmonic area in the second–third left interspace. At a later date, there is a continuous harsh, loud, systodiastolic machinery murmur (a coffee-mill murmur, "souffle continu a renforcement systolic"). This murmur is also heard in the back, in the lumbodorsal region. Should only a systolic murmur be present in adults, the diastolic component is either masked or is beyond the reach of the ear because of its low intensity or its high frequency or both.

It is evident that the symbolic presentation of congenital cardiopathies is more clear, concise, and complete than the usual longhand description.

4. Auscultatory Changes following Cardiovascular Surgery

Following cardiovascular surgery, murmurs change in character: they become louder or softer, they may disappear completely and definitively, occasionally they may reappear, sometimes new murmurs appear which did not exist before the operation and which are a result of surgicial intervention

Rates and rhythms also change, extrasystoles, atrial flutter, or atrial fibrillation may replace the regular sinus rhythm either temporarily or permanently.

In order to illustrate the results of cardiovascular surgery, mention is made only of the most frequent operations, namely, valvuloplasty for mitral stenosis, and section (and ligation) of patent ductus arteriosus

Valvuloplasty for Mitral Stenosis (Fig. IX)

CASE No 1

Before Operation (a). The picture shows a red dented area with a crescendo symbol, a blue line numbered 1, a double blue line numbered 2, and a blue line numbered 3 (presystolic rumbling crescendo murmur best heard over the mitral region in the fifth interspace; the patient is in a recumbent position; and a split second sound is heard over the pulmonic area as well as an opening snap of the mitral valve over the apex). The pulse is 84 per minute.

Following Valvuloplasty (b). The picture is similar to (a) except that the red shading has disappeared, since the murmur is no longer heard. The other features concerning the heart sounds remain the same, but the pulse is now 68 per minute. The commissurotomy was apparently successful.

CASE No. 2

Before Operation (c). The picture is similar to (a), but the pulse is 80 per minute.

Following Valvuloplasty (d). The picture is similar to (b). Indeed, the red shading is missing, and the murmur has disappeared, but the regular sinus rhythm is now replaced by an atrial fibrillation with a ventricular rate of 90 per minute: 400/90.

Ten Days Later (e). The picture looks similar to (c), and, in addition, there is a red symbol with a smooth surface, containing an arrow and a bass clef (a soft systolic apical murmur with a musical component, low in pitch, radiating toward the left axilla). Atrial fibrillation persists with a ventricular rate of 76 per minute: 400/76.

Although the surgery was successful and the patient became symptom free, a murmur of mitral insufficiency, which did not exist preceding the operation, was heard, together with the presystolic murmur which prompted the operation and which reappeared.

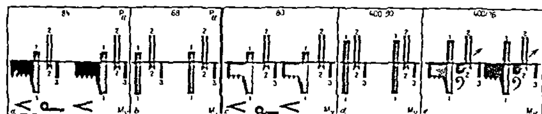


Figure IX. Mitral stenosis before and after commissurotomy.

Case No. 1

a. A middiastolic rumbling is followed by a presystolic murmur (red symbol) that terminates with an accentuated first apical heart sound (1), the second sound (2) is split (over the base), and the opening snap of the mitral valve (3) (this is not the third heart sound) is visualized over the apex. The patient is in a recumbent position

b. Following commissurotomy, the rumbling and murmur have disappeared. (The frame contains only blue symbols)

Case No 2

c This frame represents mitral stenosis, previous to surgical intervention (similar to *a*).

d. Following commissurotomy, the murmur has disappeared (as in *b*).

[illegible]

sound, which is best heard over the base, is here charted in the pulmonic (P_{II}) area.

Section for Patent Ductus Arteriosus (Fig. X)

CASE NO. 1

Before Section (a). The picture shows a red wave-like dented shading, containing a blue line numbered 2, and there is a bent red symbol (continuous machinery murmur, "à renforcement systolique," best heard in the pulmonic area, second interspace, when the patient is seated). The pulse is 76 per minute.

Following Section (b). The picture does not contain any red symbols, the murmur has disappeared, and the pulse is now 64 per minute. This was a successful operation.

CASE NO. 2

Before Surgery (c). The picture is similar to (a), but the murmur is loud (F), with the symbols of crescendo and decrescendo.

Following Ligation (d). The picture is similar to (b). There is no red symbol because no murmur was heard, the pulse is now 76 per minute, and the two blue lines represent the first and second heart sounds. The operation seemed apparently successful.

Six Months Later (e). The picture shows the reappearance of the murmur heard before the operation, and the red symbol is characterized by a treble clef 𝄞 (the murmur has a musical component high in pitch, the second blue line has a blue disk below—masked sound, and the symbol FF indicates that the murmur is very loud). It is evident that the reappearance of the machinery murmur is due to *recanalization.*

Cardio-Charting helps to evaluate surgical results. Indeed, a single glance at the blue-red frames representing the clinical findings preceding and following operation is sufficient to see the results of the cardiac surgery. The immediate results can thus be evaluated while in the operating room, and, *at a later date, one can see whether these results are transitory or* permanent.

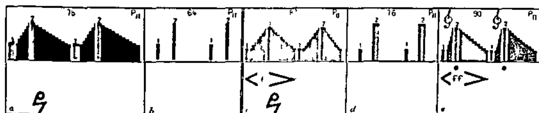


Figure X. Patent ductus arteriosus before and after operation.

Case No. 1

a. A systodiastolic, machinery (or coffee-mill) murmur—continuous, wave-like red dented symbol, which is characterized by systolic accentuation, is best heard over the pulmonic area. The patient is in a sitting position

b. Following *section* of the patient ductus arteriosus, the murmur has disappeared (The frame contains no red symbols.)

Case No 2

c. Patent ductus arteriosus before surgery (*see a*) The murmur is loud (F), crescendo-decrescendo

d Following *ligation* of the patent ductus arteriosus, the murmur has disappeared (as in *b*).

e. Six months later Recanalization has occurred with reappearance of the machinery

5. Concise Presentation of Many Cardiac Examinations

Figure XI reveals at a glance the cardiac status of ten years, each frame showing the yearly auscultatory findings. Thus it is easy to follow the entire evolution of the illness in a chronologic sequence of events with Cardio-Charting. Here is the visual reproduction of the acoustic cardiac phenomena which are presented clearly and briefly.

In the previous illustrations the sounds and murmurs of individual examinations were clearly presented, because of the colored symbols Here, since the frames are placed side by side, ten years of changing cardiac conditions are illustrated on one single line and viewed easily and quickly.

CASE NO. 19

In *1947*, a 35-year-old housewife was examined for the first time. There was a regular sinus rhythm with a pulse of 72 per minute. No murmurs were heard, and the patient was symptom free. The blood pressure was normal, and the fluoroscopic examination showed that the heart was normal in size, shape, and position.

In *1948*, a systolic functional murmur was present over the mitral region, the fifth interspace, and was best heard when the patient was seated The pulse was 80 per minute.

In *1949*, the patient was symptom free, but the pulse rose to 90 per minute No murmur could be elicited, even after exertion.

In *1950*, following the first attack of rheumatic fever, the patient had signs of mitral stenosis and mitral insufficiency This frame shows the presence of a rumbling presystolic crescendo murmur, the first heart sound, a soft systolic murmur radiating toward the left axilla, and the opening snap of the mitral valve (a red dented symbol followed by a blue line numbered 1, then a smaller red symbol followed by a blue line numbered 3—all this over the apex, M_V). Over the base (pulmonic area) the split

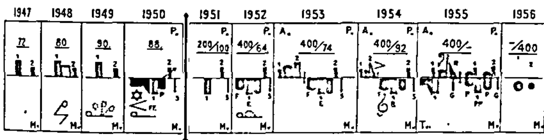


Figure XI. Ten years of cardiac auscultation viewed at a glance.

1947. Normal heart.

1948 Functional murmur—outline of a red symbol, the patient is seated.

1949. Normal heart No murmurs are heard even following exertion.

1950. Mitral stenosis and mitral insufficiency The presystolic murmur is predominant (asterisk), commissurotomy is performed (red vertical line).

1951 No murmurs are heard, atrial flutter is present, with a ventricular rate of 100. 200/100

1952. Mitral stenosis and mitral insufficiency. Atrial fibrillation with a ventricular rate of 64. 400/64. The murmurs are best heard at the end of inspiration while the patient is in a recumbent position

1953. Mitral stenosis, mitral insufficiency, and aortic stenosis. Atrial fibrillation with a ventricular rate of 74 400/74

1954 Mitral stenosis, mitral insufficiency, aortic stenosis, and aortic insufficiency. Presystolic murmur with a musical component, high in pitch (treble clef). Atrial fibrillation with a ventricular rate of 92 400/92

1955 Murmurs are heard throughout the precordium. Atrial fibrillation, but the pulse rate could not be determined 400/–. A protodiastolic gallop is heard over the apex (G) The systolic murmur over the aortic area has a musical component, low in pitch (bass clef)

1956 There is ventricular fibrillation –/400, no sounds or murmurs could be heard The two blue disks represent the absent heartbeats.

›f the second sound (double blue line numbered 2) could be heard. The ›ulse was beating at 88 per minute.

Because of heart failure with cyanosis, ankle edema, dyspnea, and ›alpitation and because the presystolic murmur was predominant, a valvuloplasty was suggested and performed (vertical red line with arrow ›eads).

Following cardiac surgery the patient improved greatly. This condition of well-being lasted for six months during which period the patient was symptom free.

In *1951*, no murmurs were heard (absence of red symbols), but the split second sound and the opening snap of the mitral valve persisted. Atrial flutter replaced the regular sinus rhythm, and the ventricular rate was 100: 200/100.

In *1952*, the patient was progressively developing heart failure. Atrial fibrillation followed the flutter. 400/64. Presystolic and systolic murmurs (red symbols before and after blue line numbered 1) were heard; the latter was softer than the murmur which was present before surgery. This murmur was clearly heard when the patient was holding her breath, while in a recumbent position.

In *1953*, in spite of cardiotonics, the condition of the patient continued to deteriorate. The atria were fibrillating, and the ventricular rate was 74 per minute. 400/74. In addition to the presystolic and systolic murmurs heard over the apex, a systolic murmur over the base appeared (red symbol between the first and second blue lines over the aortic area).

In *1954*, the patient continued fibrillating with a ventricular rate of 92 per minute: 400/92. In addition to the previously described murmurs, an aortic diastolic murmur appeared because of insufficiency (red symbol with a decrescendo sign following immediately the preceding line numbered 2) over the aortic area. The presystolic apical murmur changed in character, and a high-pitched musical component was now heard (treble clef 𝄞).

In *1955*, in spite of cardiotonics, bed rest, diuretics, and oxygen therapy, the condition of the patient grew constantly worse. Murmurs were heard now over the four cardiac areas. While the soft high-pitched presystolic musical component disappeared over the mitral region, a rough but low-pitched musical systolic murmur (bass clef 𝄢) could now be heard over the aortic area The additional murmurs were: a presystolic murmur over the tricuspid region (red dented symbol over T_{11}) and a systodiastolic murmur over the pulmonic area (red symbol preceding and following the first sound over the pulmonic area, second interspace). A protodiastolic gallop over the apex (blue vertical symbol with the letter G) set in, and was best heard over the mitral and the tricuspid areas. The patient was

fibrillating, and no pulse could be obtained: 400/—. It was difficult to ascertain whether the murmurs described were autonomous or transmitted from the mitral and the aortic areas.

In *1956*, complete heart failure was present. No sounds or murmurs could be elicited, and the patient died following ventricular fibrillation (—/400).

It is obvious that a complete and precise description of these events taking place during ten years would have filled a number of pages and would have taken time to read. And the reading would only be possible in the language of the author's country. This illustration of Cardio-Charting shows instantly all the changes, which took place during ten years, gathered together, including surgery with its results. Moreover, due to absence of words, such a notation (charting and reading) is easy to apply by any physician throughout the world

It is doubtful whether it would have been possible to secure such a complete and concise record of ten years except with these colored symbols.

6. Cardio-Charting and Audio-Viso-Cardiography

COLORED SYMBOLIC PRESENTATION AND ELECTRO-MECHANICAL RECORDINGS (FIG. XII)

Cardio-Charting does not convert an audible sound into a visual pattern, but it helps to recall the acoustic phenomena perceived during auscultation of the heart. It also discloses instantly and clearly whatever the observer has actually heard. Thus, Cardio-Charting helps to recall the past clinical findings in their chronologic succession. The handwritten chart cannot have the precision of graphs obtained with mechanical or electrical instruments, however, it is the simplest illustration of the examiner's findings, including interpretation. This charting is also helpful in objectivating the individual findings, insofar as it is impossible to know what an observer hears and it is difficult to write exactly and clearly one's own personal auditory perceptions

Audio-viso-cardiography represents three records: the stethogram, the electrocardiogram, and the magnetic sound tape. The tracings secured through mechanical or electrical devices, and which are unquestionably helpful, particularly for timing, are not always in relationship with the clinical findings. Indeed, there is discrepancy between the audible heart sounds and murmurs and the same findings reproduced graphically. A loud murmur of great intensity may be represented by a very small tracing, while a very soft murmur can be recorded and visualized as a large tracing It is known that the doctor is the one who makes the diagnosis, not the instrument, no instrument can substitute for the human ear, which is able to discriminate among sounds of different nature The ear also hears, at the same time, the heart sounds, as well as the murmurs, whereas the electrocardiogram always precedes the stethogram, although both are taken simultaneously. Many heart diseases can be and are diagnosed by the

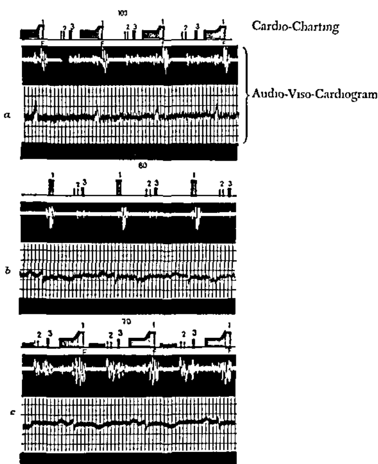


Figure XII. Cardio-Charting and audio-viso-cardiography.

a. The red and blue symbols indicate clearly the clinical findings the heart rate is 100 per minute, over the mitral area in the fifth interspace, a middiastolic rumbling, followed by a presystolic crescendo murmur (red symbol), is visualized, the split second sound (2) and the opening snap of the mitral valve (3) are charted Below the Cardio-Chart is presented the audio-viso-cardiogram first, the stethogram showing the presystolic murmur, the split second sound, and the opening snap of the mitral valve, underneath, the electrocardiogram with a small P wave, an upward QRS complex with a [illegible] base represents [illegible] which can [illegible] the one on [illegible] during the clinical examination of the heart

b One day following commissurotomy The pulse rate is 80 per minute, the *Cardio-Chart* shows only the heart sounds, no murmurs are charted (absence of red symbols) since none was heard The *stethogram* shows only the presence of the sounds, with absence of oscillations from murmurs The split second sound and the opening snap of the mitral valve are present as prior to commissurotomy The *electrocardiogram* which has changed shows a deep S wave, a depressed ST segment, and an inverted T wave The violet line at the base, which represents the *sound tape*, when played back, reproduces audibly only heart sounds [*Caption continued on page 48*]

6. Cardio-Charting and Audio-Viso-Cardiography

COLORED SYMBOLIC PRESENTATION AND ELECTRO-MECHANICAL RECORDINGS (FIG. XII)

Cardio-Charting does not convert an audible sound into a visual pattern, but it helps to recall the acoustic phenomena perceived during auscultation of the heart. It also discloses instantly and clearly whatever the observer has actually heard. Thus, Cardio-Charting helps to recall the past clinical findings in their chronologic succession. The handwritten chart cannot have the precision of graphs obtained with mechanical or electrical instruments; however, it is the simplest illustration of the examiner's findings, including interpretation. This charting is also helpful in objectivating the individual findings, insofar as it is impossible to know what an observer hears and it is difficult to write exactly and clearly one's own personal auditory perceptions.

Audio-viso-cardiography represents three records: the stethogram, the electrocardiogram, and the magnetic sound tape. The tracings secured through mechanical or electrical devices, and which are unquestionably helpful, particularly for timing, are not always in relationship with the clinical findings. Indeed, there is discrepancy between the audible heart sounds and murmurs and the same findings reproduced graphically. A loud murmur of great intensity may be represented by a very small tracing, while a very soft murmur can be recorded and visualized as a large tracing It is known that the doctor is the one who makes the diagnosis, not the instrument, no instrument can substitute for the human ear, which is able to discriminate among sounds of different nature The ear also hears, at the same time, the heart sounds, as well as the murmurs, whereas the electrocardiogram always precedes the stethogram, although both are taken simultaneously Many heart diseases can be and are diagnosed by the

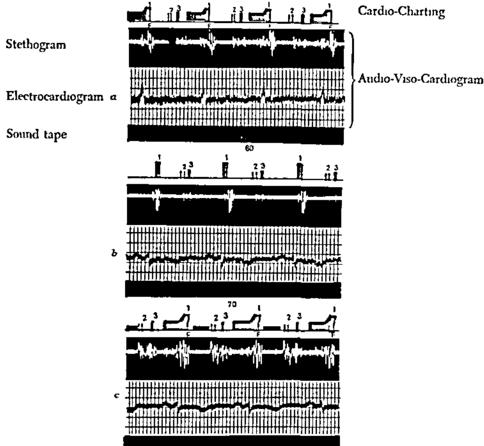


Figure XII. Cardio-Charting and audio-viso-cardiography

a. The red and blue symbols indicate clearly the clinical findings the heart rate is 100 per minute, over the mitral area in the fifth interspace, a middiastolic rumbling, followed by a presystolic crescendo murmur (red symbol), is visualized, the split second

slightly notched upward limb, and an upward T wave The violet line at the base represents the magnetic sound tape, containing the audible sounds and murmurs, which can be heard when played back on a machine running at the same speed as the one on which the tape was originally recorded and which actually were heard during the clinical examination of the heart

b One day following commissurotomy The pulse rate is 80 per minute, the *Cardio-Chart* shows only the heart sounds, no murmurs are charted (absence of red symbols) since none was heard The *stethogram* shows only the presence of the sounds, with absence of oscillations from murmurs The split second sound and the opening snap of the mitral valve are present as prior to commissurotomy The *electrocardiogram* which has changed shows a deep S wave, a depressed ST segment, and an inverted T wave The violet line at the base, which represents the *sound tape*, when played back, reproduces audibly only heart sounds *[Caption continued on page 49]*

examining physician through auscultation alone without the use of any instrument. Nonetheless, instruments are helpful, particularly in questionable cases to confirm or deny a clinical suspicion. Recently, the principle of the cathode-ray oscilloscope has been used for the demonstration of cardiac acoustic phenomena, but, here, the sounds and murmurs, which are visualized, have to be studied while the visual waves are in constant motion. The Cardio-Chart, on the contrary, is a permanent and static record which can be studied easily and without the aid of instruments.

Figure XII is a comparison of the audio-viso-cardiogram (stethogram, electrocardiogram, and magnetic sound tape) with the superimposed Cardio-Chart. While the audio-viso-cardiogram has been recorded (objectively), the Cardio-Chart is neither an interpretation of the underlying tracings nor of the sounds and murmurs played back on a magnetic recorder, but the actual acoustic phenomena *heard* by the examiner's ear. Moreover, while the Cardio-Chart is understood at a glance, and the murmurs, if present, have only to be defined, the instrumental tracings always need to be explained and interpreted.

The comparison between both-mentioned methods (subjective and objective) is useful since it shows the qualities as well as the shortcomings of each one of them.

c Ten days later The pulse has slowed down to 70 per minute The Cardio-Chart shows, in addition to the findings visualized in *a* (namely, a presystolic murmur—red symbol pre[illegible]
blue line) [illegible]
insufficienc[illegible]
yet fails to[illegible]
Cardio-Chart The electrocardiogram is similar to the one above (*b*). The sound tape enables the listener to hear, when reproduced, the same findings as observed clinically, namely, a presystolic murmur of mitral stenosis and a systolic murmur due to insufficiency of the mitral valve, following commissurotomy.

7. Advantages; Applications; Résumé and Conclusion

ADVANTAGES

The described method is a system of charting subjective auscultatory findings, and therefore questionable because of our imperfect senses and because of our interpretations which may vary. Nevertheless, it has many advantages

1. Cardio-Charting is a handmade method which does not require the use of any instrument.

2. It is timesaving Cardio-Charting requires but little time and space for the diagram which is understood instantly.

3. The method is very simple—blue symbols for heart sounds, red for murmurs Without special studies every physician can become instantly familiar with Cardio-Charting

4. It is comparative The Cardio-Chart is a permanent and comparative record which helps to unfold instantly in their chronologic occurrences a succession of auscultatory findings. sounds and murmurs, with their individual characteristics

5. The use of blue and red symbols helps to secure a standardized, complete, and concrete record of the findings The record is as accurate as it is practical.

6 The specific colored symbols will help in the exchange of information among members of the medical profession, and thus the Cardio-Chart can be used as a diagnostic code Such symbols can be entrusted to patients without unduly disturbing them, because they do not reveal the diagnosis

7 Cardio-Charting is helpful wherever repeated auscultation is inadvisable because of the patient's serious condition, or in small communities where graphic instruments do not exist.

Bibliography

Boas, Ernst P., and Goldschmidt, Ernst, F : *The Heart Rate* Charles C Thomas, Publisher, Springfield, Ill., 1932

Briskier, Arthur. "New Device for Objective Auscultation of the Heart Permanent Audible and Visual Record of Heart Acoustics," *Am Heart J.*, 45:914-17, 1953.

———: "L'enrég [illegible]

———: "L'Audio-Viso-Cardiographie," *Arch. Mal. Coeur et Vais*, Mai, 1953.

———: "Une Méthode Universelle de Notation Cardiaque. La Cardio-Notation," *La Presse Medicale*, 22 Fevrier 1956, pp. 343-46

Calgren, L E., "Gallop Rhythm in Children, Studied by Means of Calibrated Phonocardiography," *Acta paediat*, Vol. 33, Suppl. 6, 1946

Cossio, P ; Orias, O ; and others *Temas de Fonocardiografia* El Ateneo, Buenos Aires, 1935.

Dressler, William, and Roesler, Hugo *Atlas of Electrocardiography.* Charles C Thomas, Publisher, Springfield, Ill , 1949

Fletcher, Harvey *Speech and Hearing in Communication,* 2nd ed D. Van Nostrand Co , Inc., New York, 1953

Jagic, N.. *Perkussion und Auscultation* Urban und Schwarzenberg, Berlin, 1932

Katz, Louis N.: *Electrocardiography,* 2nd ed Lea & Febiger, Philadelphia, 1946

Leatham, Aubrey. "Phonocardiography," *Brit M Bull*, Vol 8, Issue 4, 1952.

Levine, Samuel A.: *Clinical Heart Disease*, 4th ed W B Saunders Co, Philadelphia, 1951

Lewis, Thomas *The Mechanism and Graphic Registration of the Heart Beat* Shaw & Co , Ltd , London, 1925

Lian, C , Minot, G , and Welti, J J *Phonocardiographie* Masson & Cie, Paris, 1941.

Luisada, Aldo A. *The Heart Beat* Paul B Hoeber, Inc , New York, 1953

MacKenzie, Sir James *Diseases of the Heart,* 4th ed Oxford University Press, Cambridge, England, 1925

Mannheimber, E : "Calibrated Phonocardiography and Electrocardiography," *Acta paediat*, Vol 28, Suppl 2, 1940

Martinet, Alfred, and others *Clinical Diagnosis, Case Examination and the Analysis of Symptoms,* 3rd ed. F A Davis Co , Philadelphia, 1928

Muller, Fredrick, and Seifert, Otto: *Taschenbuch des Medezinisch-Klinischen-Diagnostik.* J. F. Bergman, Munchen, 1949

Orias, Oscar, and Braun-Menéndez, Eduardo: *The Heart Sound in Normal and Pathological Conditions.* Oxford University Press, Cambridge, England, 1939

Pardee, Harold E B.: *Clinical Aspects of the Electrocardiogram,* 4th ed. Paul B. Hoeber, Inc., New York, 1941.

Potter, Ralph, and others: *Visible Speech.* D. Van Nostrand Co., Inc., New York, 1947.

Prinzmetal, Myron, and others: *Auricular Arrhythmias.* Charles C Thomas, Publisher, Springfield, Ill, 1952.

Rappaport, M. B, and Sprague, H. B.: "Physiologic and Physical Laws That Govern Auscultation and Their Clinical Application," *Am. Heart J*, 21:257, 1941.

———, and ———: "The Graphic Registration of the Normal Heart Sounds," *Am. Heart J.*, 23:591, 1942.

Roth, Irving R.: *Cardiac Arrhythmias.* Paul B Hoeber, Inc., New York, 1928.

Sahli, Hermann: *Treatise on Diagnostic Methods of Examination,* 2nd ed. W. B Saunders Co., Philadelphia, 1911.

Segall, H. N.: "On Writing Symbols to Describe Cardiovascular Sounds and Murmurs While Listening," *Am. Heart J.*, 33:705, 1947.

Siebert, W. W.: *Der Perkussionskurs.* Georg Thieme, Verlag, Leipzig, 1942.

Smith, A. L.: "A Method of Recording and Reproducing Fetal Heart Sounds," *Am. J. Obst. & Gynec.*, 40:102, 1940.

Smith, J. R.; Edward, J. G, and Kountz, W. B.: "The Use of the Cathode Ray for Recording of Heart Sounds and Vibrations," *Am. Heart J.*, 21:288, 1941.

White, Paul Dudley: *Heart Disease,* 4th ed. The Macmillan Company, New York, 1951.

Index